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ABSTRACT

Research indicates that there are numerous opportunities for educators to use computer technology in ways which are developmentally appropriate and which support or enhance preschool children's natural motivation to explore and discover. Since many of the misconceptions about preoperational cognition that form the basis for serious objections to preschool computer use have been dealt serious blows in recent years, the microcomputer should not be viewed as different from any of the other materials commonly used in early childhood classrooms. When the computer is used appropriately, it has the potential to involve children more than television does; it is less static than picture books, and as open-ended as crayons. In particular, discovery-oriented child-computer environments, "microworlds," or simulations have numerous potential uses, such as modeling concepts, exposing processes which are not available in all their facets to the perception of young children, providing intrinsic motivation, connecting different ways of learning, and serving a "scaffolding" function. Finally, the computer is worthy of inclusion in the early childhood classroom simply as a part of the everyday world which is to be explored, manipulated, and understood. To argue that the young child should be protected from exposure to computers is tantamount to keeping the electric toothbrush under lock and key. A 55-item reference list concludes the document. (RH)

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Microcomputers and Preschoolers: Bandwagon or Boon

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Increased accessibility to microcomputers has given rise to a tremendous surge of interest in their potential influence in preschool education. The proliferation of personal computers from college courses to nursery schools and into the home, prompted Kelman (1982) to lament the lack of time taken to reflect upon the pedagogical, psychological, and ethical issues. Since then proponents have arisen on both sides of the issue. Whereas some (Barnes & Hill, 1983; Cuffaro, 1984) have warned that young children should not be involved with microcomputers, others (Watson, Nida, & Shade, 1986; Ziajka, 1983) have cautiously, albeit enthusiastically, argued otherwise. Barnes and Hill warned that the preschool child's preoperational thinking limits the usefulness of microcomputers and requires the child's total immersion in "real-life" activities. Cuffaro added that young children who use computers experience "action in a vacuum, motion without context, and reality twice removed." On the other hand, Ziajka (1983) pointed out that the microcomputer provides an opportunity for young children to engage in symbolic representation, a feat well within the preoperational child's repertoire (see semiotic function, Piaget, 1970). He further stated that, "someday we may want to add computer-generated images on a screen as a new form of representation that the child evokes and manipulates." To many (Piestrup, 1985; Sheingold, 1986) this is not far removed from other childhood activities which deal with symbols such as looking at picture books, speaking, dramatic play, singing and making objects out of clay. Watson, Nida, and Shade (1986) have further concluded that the microcomputer should be viewed as any educational tool, no better or worse than books, crayons, paper, television, or Lego blocks.

It should be noted that many of the misconceptions about

preoperational cognition that form the basis for serious objections to preschool computer use, have been dealt serious blows in recent years. Watson, Nida, and Shade (1986) took issue with the notion that children must reach the concrete operations stage before they are ready to work with a microcomputer. They pointed out that the time had come for educators to apply cognitive theory to computers in early childhood education. Besides the fact that the most recent issue of Mussen's Handbook of Child Psychology questions the notion of broad stages of cognitive development, each characterized by qualitatively distinct structures (Gellman & Baillargeon, 1983), recent research indicates that preschool children are not as egocentric as previously thought (Lempers, Flavell, & Flavell, 1977; Masangkay, McCluskey, McIntyre, Sims-Knight, Vaughn & Flavell, 1974), nor as perceptually limited in conservation tasks (Markman, 1979). They can distinguish between appearance and reality (Fein, 1979), and can follow the transformation of objects from one state to another (Gelman, Bullock & Meck, 1980). Furthermore, recent studies conducted at the Genevan School (Karmiloff-Smith & Inhelder, 1975) concluded that preoperational children can often solve problems that require concrete operational structures.

Many critics of computer use by young children (Barnes & Hill, 1983; Cuffaro, 1984; Streibel, 1984) still question if this applies to learning from a two-dimentional screen, a question which should never have been raised since it ignores the numerous studies which have investigated children's comprehension of information delivered via television (Collins, Wellman, Keniston, & Westby, 1974; Wright & Huston, 1981). Streibel attempted to justify these conslusions by pointing out that computer graphics are nothing more than some programmer's view of the world formalized into quantitative

algorithms. Although this is an accurate description of computer graphics reduced to their simplist form, it smacks of eliminating picture books from your curriculum because children do not understand photoduplication. In an effort to deal with these types of criticisms, Shade and Watson (1987) recently developed microworld software to teach three-year-old children to classify a unique array of objects (table, car, lamp, etc.) by the simple concept of inside/outside; a task strict interpretations of cognitive stage-theory would consider outside of the three-year-old's range of abilities. Forty-one preschool children, 18 to 42 months, spent a total of one hour manipulating graphic objects in and around the background scene of a house and yard. The two- and three-year-olds were randomly assigned to two groups; one received the inside/outside microworld and the other worked with software that drilled the alphabet. Although there were no significant differences between groups, the age by treatment interaction approached significance ($p=.053$). In other words, the mean number of real objects correctly classified on the post-test by three-year-olds in the microworld group was larger (8.27) than the alphabet three-year-olds (5.22). Post hoc power calculations (phi = 1.86, power = .53) revealed that a strong effect was present in the interaction and that significance was not reached because of the small sample size ($n=10$) in each cell. In other words, this electronic houseplay enabled children as young as 3 years (mean age 2.83) to construct knowledge and correctly classify a series of real objects when tested at the conclusion of the study. These particular three-year-olds also showed the greatest task persistence as evidenced by a moderately high correlation between the age of the child and the total time spent at the computer ($r=.49$, $p=.024$). Furthermore, they learned to classify or sort significantly better

than the two-year-olds in the same group who sorted no better than any of the children in the alphabet-drill group. Others (Brinkley & Watson, 1986) who have replicated or performed similar research (Calvert, Watson, Brinkley, & Bordeaux, 1987; Watson, Calvert, & Popkin, 1986) have also found microworld software to have significant potential for enhanced discovery-learning in young children three- to five-years old.

Based upon the findings of this particular study it was concluded that young preschool children can indeed learn from a vertical, two-dimensional plane (video screen). It was further concluded that age of first introduction to the computer is dependent upon software content and competencies required. Microworld software requires much more of the young child than a single-key operated, alphabet drilling program. Therefore, it was recommended that age three be earmarked as an appropriate time to introduce children to discovery-based software that requires sequential manipulation of several keys. This recommendation was based upon the three-year-olds success in manipulating and learning from the microworld.

Another of the supposed threats to young children centered on the computers power to make social isolates of them (Barnes & Hill, 1983; Heller & Martin, 1982) and consequently disrupt development. Lipinski, Nida, Shade, & Watson (1986) recently completed a comprehensive two-study project investigating the effects of microcomputers on children's social behavior and free-play choice in a preschool classroom. Thirty-four children, 12 in Experiment 1 and 22 in Experiment 2, were observed during sixteen, one-hour free-play periods. Social interaction was measured using nine behaviors from the Friedrich and Stein Observational Scale (1973) (cooperation, helping/sharing, praise, initiating social interaction, physical aggression,

verbal aggression, nonverbal aggression, object aggression, asking adults for help) and three additional behaviors identified specifically for this research (verbalization toward adult, verbalization toward child, looking at microcomputer). Free-play choice was observed by recording the location of each child on a classroom diagram at 5 minute intervals. All of these behaviors were observed while children selected activities among traditional classroom play areas: art, blocks, dramatic play, manipulative toys, and from the computer area. A microcomputer with age-appropriate software was placed in each classroom with the following treatment weeks: baseline, computer-interactive and computer-teacher-interactive. Results indicated that just as many social behaviors occurred around the computer as in the other play areas. Rarely were children observed alone at the computer. Rather they came to the computer in groups of two or three collaborating with each other about computer use and software content. In the Barnes and Hill article (1983) attention was drawn to the social benefits children derive from block play, art, and manipulative toys. Yet, the Lipinski et al. study reported that no more talking and/or other positive social behaviors occurred in these areas than in the computer area.

The following was discovered in terms of free-play choice. When the microcomputer was first introduced into the classroom, there was an initial disruption of almost all free-play areas. It was concluded that this effect was due to the novelty of the microcomputer, for as time passed most play areas returned to their baseline level. It should be noted, however, that one area in each classroom did not recover from the initial disruption and differed for each classroom. Which play area is affected on a long-term basis by the addition of a microcomputer is probably a function of the individual

classroom and/or the particular group of children. For example, in Experiment 1, dramatic play never recovered; in Experiment 2, it was the most popular area. The two classrooms differed in what was available for dramatic play on a daily basis. One classroom had the same dressup and houseplay materials available each day, while the other classroom had a different theme and novel play materials everyday.

Further support for the computers' positive role in the early childhood classroom was found in the research of Shade, Nida, Lipinski and Watson (1986). A total of thirty-one preschool children (mean age 4.5), 11 in Study 1 and 20 in Study 2, were observed using a "Time Sampling" method from a seat located near the microcomputer. A one-hour self-selected activity period was observed for four days each week (skipping Mondays) for four consecutive weeks in Study 1 and three consecutive weeks in Study 2. The observer at the "computer station" recorded behaviors between children at five-minute intervals. Child behaviors were identified as (a) positioning for a turn at the computer, (b) assisting one another at the computer, (c) enforcement of rules concerning computer use, and (d) domination of the computer station. Several interesting trends were observed for both groups. For example, children's behavior changed from positioning for a turn in the first week to assisting one another during the last week. Specifically, the children were observed to assist other children in keyboard manipulations and the "booting up" of software. It is also interesting to note that domination of the computer station decreased from the first to last week. A further trend warrants emphasis. During the first weeks children generated a set of rules for computer use. Although at times the rules were a bit egocentric, they nevertheless emphasized turn-taking, sharing, and helping. Self enforcement

of these rules increased in both studies, as the weeks progressed, however the nature of the rules changed. In the first weeks enforcement centered around turn-taking. By the final week rule enforcement centered on proper use of the computer and software. Thus we can see that young children do not become social isolates when computers are present.

Some of the more recent criticisms (Elkind, 1985, 1987) seem to stem from misinformation about what software is actually available for young children and what that software is really like. Elkind's assertion that the only computer activities currently available to young children are programming and programmed learning, is a gross misrepresentation of computer use in early childhood education and an insult to those who thoughtfully include computers in their curriculum. Truly, programming per se is out of the young child's intellectual reach (Cuneo, 1985). However, one should not discount the pre-programming activities available through simplified versions of Logo (Clements, 1984; Rosen, 1985) and programs like Delta Drawing (Aronson, 1982). Using simple single-keystroke commands, young children can create a design, print it, take it home and hang it on the refrigerator. This is a powerful experience that is centered more on the child's self-concept than intelligence quotient. Furthermore, children need not be subjected to programmed learning to use microcomputers. Software is available that provides open-ended discovery experiences congruent with many principles of Piaget's constructivism. Recently Haugland and Shade (in press) developed ten guidelines and a scoring system for evaluating the developmental appropriateness of software. With these guidelines early childhood teachers can plan and choose microcomputer activities appropriate to developmental philosophy. The guidelines contain many familiar tenets of early childhood

curriculum development as well as developmental theory. It is an oversimplification of the scale, but one could say the higher the overall score a piece of software receives, the less it will be like programmed learning (drill and practice). In their article, Haugland and Shade (in press) include evaluations of eight popular early childhood software programs.

From Bandwagon to Boon

Discovery oriented child-computer environments, "microworlds" (Haugland & Shade, in press; Papert, 1980a) or simulations (Lepper, 1985) as they are usually referred to, have great potential to swing the computer pendulum from bandwagon to boon. Several of the researchers reviewed above (Brinkley & Watson, 1986; Calver, Watson, Brinkley, & Bordeaux, 1987; Shade & Watson, 1987) have shown that young children can not only manipulate such software but learn from it as well. Others (Haugland & Shade, in press) have made it possible to determine how "microworld-like" a software program actually is.

A microworld is an open-ended, child-oriented, software experience where children have direct access to specific concepts as well as the ability to exercise those concepts in personally meaningful ways. With computer activities such as these, virtually any concept, from the complexities of geometry to the simplicity of things that go inside or outside, can be modeled or simulated. Of course when Papert (1980a) first introduced microworlds he was referring to Logo, the turtle, and turtle-geometry. Taylor (1980) described this as the "tutee" mode. Through programming, or "teaching" the turtle what to do, children come into contact with their own thinking as well

as the geometric concepts hidden behind the attractiveness of the turtle as an object with which to think.

A more expanded view of this software format relieves the child of programming and retains the interactive nature and child-in-control aspects essential to discovery based learning. For example, Robert Lawler (1982a, 1982b) designed a microworld called "beachworld" in which his three-year-old daughter manipulated (through simple keyboard functions) twenty computer graphics such as a sun, car or ball. The child typed in the word "sun" from a 4x6 card and instantly a graphic sun would appear in the clouds above the beach. At first the child did not know the words and only knew a few letters of the alphabet, however, in three months she had learned to read the 20 words she had used to create her beach pictures. Furthermore when tested, by randomly picking the same words off a printed page, she could read and relate their meaning.

Expanding upon this notion, Chaille and Littman (1985) discussed the possibility that computer simulations or microworlds could serve as "process highlighters" for young children. As such they can be used, in conjunction with related real-world object-based activities, to expose "hidden processes" or cause-and-effect relationships, thus increasing the efficiency of the young child's natural hypothesis testing. Chaille and Littman used the pendulum as an example of a hidden process that traditional early childhood materials do not access. Since a real pendulum swings too rapidly for children to observe the trajectory, they are limited in their ability to engage in a level of theory building or knowledge construction which they might were conditions otherwise.

This kind of software experience differs a great deal from typical

drill-and-practice. The child's motivation to participate in the learning experience comes from his/her enjoyment of the exploration process and chance to supply or invent the structure rather than master someone else's (Kerkman & Wright, 1984). In fact, microworld software or simulations (Lepper & Malone, 1985) provide intellectually rich and intrinsically motivating learning environments that maximize the conditions under which discovery learning should be expected to occur. Microworlds (Lepper, 1985; Lepper & Malone, 1985; Malone, 1983; Malone & Lepper, 1985) include four of the major factors influencing intrinsic motivation: challenge, curiosity, control, and fantasy.

The *challenge* of Lawler's beachworld or Chaille and Littman's "process highlighter" comes from a number of things. The goal of the activity, making a beach picture or hitting the target with a swinging object, is personally meaningful to the child and there are endless possibilities for experimentation. Furthermore, the graphic feedback (pictures in beachworld, instant-replays in "process highlighter") provided a sense of personal achievement and competence (Chaille, & Littman, 1985; Lawler, 1982b). Children, using software similar to Lawler's beachworld (Shade, 1986), have been observed to express high levels of elation and personal pride in their accomplishments. Second, the user *control* of this software format gives children power to construct their own knowledge about the phenomenon; much like blocks and sand. Kee (1981) expounded on control. If the child perceives him/herself to be the origin of behavior, he/she is said to be intrinsically motivated. If not, the child feels like a pawn and motivation becomes extrinsic. Third, the learning of letters and words or the improvement of aim which resulted from understanding trajectory is made incidental to the

child's natural *curiosity* about the software. In other words, rather than drilling children to death and teaching them that learning is painful, this software capitalized on children's natural tendency to explore the world, make interesting associations and discover important concepts. Finally the entire activity can be couched in a *fantasy* such as a day at the beach (still concrete enough for Piaget or familiar enough for Dewey).

Several other aspects of microworld software are of merit. Microworlds are responsive to the child's previous experience and present knowledge. Papert (1980a) and Lawler (1982b) both noted that powerful learning comes from bringing together knowledge gained in diverse experiences. The connection between past and present serves to make the experience personally meaningful to the child, an important feature mentioned previously. Papert's classic example of a child trying to draw a square with the Logo turtle illustrates this concept. When the child has difficulty controlling the turtle's direction of turn or distance traveled, he/she can walk through the activity intended for the turtle. Thus, knowledge of his/her own body and movement through space could be applied to the problem at hand. Finally, such software is accessible to preschool children because keyboard requirements can be minimized. Simplified versions of Logo requiring single key strokes are already available for young children (Clements, 1984; Rosen, 1985). Three-by-five cue cards can also be used to direct keyboarding (Lawler, 1982b), or the keyboard can be covered with stickers that highlight the keys necessary for software manipulation (Shade & Watson, 1987).

Microworlds (Sheingold, 1986) could help children to connect different ways of knowing as when children use knowledge about their own body to

debug the turtle (Papert, 1980b), use procedural thinking to plan game (Tic Tac Toe) strategies or learn to jump rope (Lawler, 1985). These experiences help children to see familiar actions and objects in new ways. Lawler (1982a) illustrated this when he discussed how playing with beachworld changed his daughter's relationship to letters and words. During the process of working with the computer the twenty beachworld words ceased to be abstract symbols and became tools for accomplishing a specific task. One could argue that seeing words as tools is something usually taken for granted or not learned until a later stage of cognitive development.

Microworlds could be developed to act as cognitive aids (Sheingold, 1986) helping children explore aspects of experiences they lack skills for. Sheingold suggested that in this sense computers serve a "scaffolding" function much as when several children work to solve a problem that would incapacitate them individually (Doise, Mugny, & Perret-Clermont, 1975; Vygotsky, 1978). Consider the example she gave of children composing music without having to learn the notation system (Brown, 1985) or being able to create stories (Quinn, Weinstein, & Schuyler, 1982) without the tedious fine-motor skills necessary for writing. Furthermore, through the process of making choices and giving instructions to the computer, children can develop a metacognitive awareness of causal relationships (Clements & Nastasi, 1985; Papert, 1980a). A young child manipulating a screen graphic to accomplish a personal goal, finds out quickly that each action is followed by an immediate consequence. Immediate results serve to bind together the child's actions and their effects; something Seligman (1975) and Brinker (1984) noted was essential in the prevention of "learned helplessness." Graphic drawing (Clark, 1983) and music construction programs (Brown,

1985) are good examples of software that can be used to provide causal links between choice, action (computer instruction) and consequence.

Conclusions

In short, there are numerous opportunities to utilize computer technology in developmentally appropriate ways to support or enhance children's natural motivation to explore and discover. It is the position of this presenter that the microcomputer should be viewed no differently than any of the other materials we utilize in early childhood education. Why should we single out this technology when certainly television, picture-books, and even crayons can be implements of miseducation? The computer, when used appropriately, has the potential to be more active than TV, less static than picture-books (Piestrup, 1985), and as open-ended as crayons (Watson et al. 1986). Furthermore, the computer is worthy of inclusion in the early childhood classroom simply as a part of our everyday world to explore, manipulate, and understand (Sheingold, 1986). If not, then all the electric typewriters, play telephones, and cash registers found in the dramatic play area should be removed. To say that the young child should be protected (Elkind, 1987) from exposure to computers is tantamount to keeping the electric toothbrush under lock and key.

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